

## **METHODS TO ACHIEVE ACCURATE PROJECTION OF REGIONAL AND GLOBAL RASTER DATABASES**

### **Principal Investigators**

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Mr. Michael P. Finn, USGS, Rolla (Mr. Finn was added to the PI list because of his significant contributions to the project during FY 2001. A brief vita follows the project workplan).

This research aims at building a decision support system (DSS) for selecting an optimum projection considering various factors such as pixel sizes, areal extent, number of categories, spatial pattern of categories, resampling methods, and error correction methods. Specifically, this research will investigate the following three goals theoretically and empirically, and using the already developed empirical base of knowledge with these results develop an expert system for map projection of raster data for regional and global database modeling. The three theoretical goals are:

- 1) The development of a dynamic projection which adjusts projection formulas for latitude based on raster cell size to maintain equal-sized cells.
- 2) The investigation of the relationships between the raster representation and the distortion of features, number of categories, and spatial pattern.
- 3) The development of an error correction and resampling procedure based on error analysis of raster projection.

### ***Hypotheses***

Regarding the first goal, we hypothesize that regional and global raster data can be accurately projected with appropriate equations which account for raster cell size and latitudinal position. For the second goal, we hypothesize that scale factors explain the impact of distortion on raster representation, and that more categories and more complex spatial patterns cause more errors. Finally, we hypothesize for the third goal that error correction and resampling methods can be used for optimizing projection accuracy of regional and global raster datasets. This proposed research potentially has impacts on all USGS programs involving the use of large regional and global raster data such as Global Change Research and Place-Based Studies.

### **FY 2001 Accomplishments**

Accomplishments to date include a web-based DSS design and initial prototype which incorporates criteria for data type, area of coverage, and qualities to be preserved. The design plans include guidance for selecting the best projection and a tutorial for map projections selection and use is to be included. For dynamic projection, global raster databases of one degree and 30 arc-sec cells containing area values computed by surface integration have been developed as the basis for the projection design to preserve the

areas. A scale factor model for error theory has been developed (publication forthcoming in *Photogrammetric Engineering and Remote Sensing*) and tested for a number of projections. The resampling algorithm is operational and is being tested. All milestones for the first year of the project have been achieved with significant results.

### **Workplan for FY 2002**

#### **Task 1: Projections Decision Support System (DSS)**

##### **Sub-Tasks:**

- 1) Refine current prototype to integrate empirical research (from GRA Task 741) and arrive at a specific recommendation for a projection based on full suite of user input. (Version 0).
- 2) Create independent web-based map projections tutorial.
- 3) Integrate map projections tutorial with DSS (Version Beta 1).
- 4) Public testing and feedback of Version Beta 1.
- 5) Incorporate feedback to modify Beta 1 DSS to generate final Version 1.

##### **Milestones/Products**

- 1) Version 0 DSS
- 2) Map projections tutorial
- 3) Version 1 Beta DSS
- 4) Documentation of public comments
- 5) Version 1 DSS

#### **Task 2 Dynamic Raster Projection**

##### **Sub-Tasks**

- 1) Apply pixel areas generated from spherical coordinates to empirical data (land cover, etc.) to compute actual total areas to be preserved.
- 2) Investigate integerized sinusoidal projection.
- 3) Develop mathematical base for data structure to preserve global raster areas computed in subtask 1.

##### **Milestones/Products**

- 1) Actual areas of land cover by category.
- 2) Recommendation of compatibility of integerized sinusoidal projection with dynamic projection goals.
- 3) Mathematical formulas for transformation of each raster line.

### Task 3 Error Theory

#### Sub-Tasks

- 1) Complete investigation of the effect of number of categories, pixel resolution, and skewing (publication of initial results in progress).
- 2) Continue application of scale factor (SF) model of other projections – global, continental, and the non-equal area class of projections.
- 3) Model total minimum accuracy in each projection.

#### Milestones/Products

- 1) Publication of Sub-Task 1 results.
- 2) Documentation of results of application of SF model.
- 3) Table of accuracies.

### Task 4 Categorical Resampling

- 1) Complete testing of resampling algorithm developed in FY 2001

#### Milestones/Products

- 1) Publication of resampling algorithm

### Task 5 Global Raster Data Storage and Analysis System Design

#### Sub-Tasks

- 1) Integrate results from Tasks 2,3,4 to establish a design for a Global Raster Data Storage and Analysis System.
  - a. Investigate a user interface/visualization method
  - b. Design analysis system with projection invisible to users
- 2) Elicit public review and comment for Global Raster Data Storage and Analysis System to determine implementation feasibility.

#### Milestones/Products

- 1) Visualization and analysis design.
- 2) Documentation of public results.

## **Publications**

Usery, E. L. and J.C. Seong, 2001. "All Equal Area Projections are Created Equal, But Some are More Equal than Others," *Cartography and Geographic Information Science*, In press to appear in July, 2001 issue.

Seong, J.C. and E.L. Usery, 2001. "Modeling Raster Representation Accuracy Using a Scale Factor Model," *Photogrammetric Engineering and Remote Sensing*, In press, to appear in October, 2001 issue.

J.C. Seong, K.A. Mulcahy, E. L. Usery, "The Sinusoidal Projection: A New Meaning for Global Image Data," Submitted to *The Professional Geographer*.

J.C. Seong, "Modeling the Accuracy of Image Data Reprojection," Submitted to *International Journal of Remote Sensing*.

E. L. Usery, T. Beard, M. Bearden, J.D. Cox, M. Finn, and S. Ruhl, "Projecting Global Databases to Achieve Equal Areas for Modeling Applications," In work, to be submitted to *Cartography and Geographic Information Science*.

### **Planned:**

D. Steinwand, "A New Approach to Categorical Resampling," To be Submitted to *Photogrammetric Engineering and Remote Sensing*.

M. Finn, E. L. Usery, J.C. Seong, and D. Steinwand, "A Decision Support System for Global Raster Data Projection," To be submitted to *Geographical Systems*

E. L. Usery and M. Finn, "Dynamic Projection of Raster Data," To be submitted to *The International Journal of Geographical Information Systems*.

J.C. Seong, "Projection Effects of Number of Categories, Pixel Resolution, and Skewing."

**Michael P. Finn**  
**Vita**

***Computer Programmer/ Analyst***

**USGS, Mid-Continent Mapping Center, Rolla, MO**

**Education**

B. S. in Geography (Environmental and Natural Resources option)

Minor in Cartography and Map Technology

Southwest Missouri State University, Springfield, Missouri, 1982

M. S. in Civil Engineering (Specializing in Geodetic Engineering)

Virginia Polytechnic Institute & State University, Blacksburg, Virginia,  
1991

**Work Experience**

2 years with DOI, USGS

- As a computer specialist, providing programming support for geographic and cartographic research projects, and developing unique solutions and one-of-a-kind and proof-of-concept systems for research; and leading the Programming Support Unit, managing student computer programmers and coordinating programming development assignments with computer scientist project leaders

17 years with US Department of Defense

- 10 years with US Air Force as a Program Analyst leading the Requirements Branch providing requirements management support to the Air Intelligence Agency; as a Computer Specialist leading the Small Computer Customer Support Branch providing maintenance, installation, troubleshooting, and training for systems to users at Patrick AFB and Cape Canaveral AS; and as a Physical Science Technician coordinating the testing of remote sensing systems being developed for the detection of electromagnetic pulses
- 7 years with Defense Mapping Agency as a Cartographer: as a systems analyst managing the Pooled Analytical Stereoplotter System; and as a scientific applications programmer, developing real-time photogrammetric data systems; as a photogrammetric cartographer producing digital terrain models

**Accomplishments**

President, Central Region, American Society of Photogrammetry and Remote Sensing  
AF Space Command Civilian Command, Control, Communications, and Computers  
Systems Professionalism Award in 1993 and 1994

45<sup>th</sup> Communications Squadron's Mid-Level Civilian of the Year Award in 1994

**Two DOI Special Thanks for Achieving Results Awards**

**Ten Performance Awards**

**Geography Award for Scholastic Achievement, SMSU, 1980**